# PATENT SPECIFICATION

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Index at acceptance:—Class 32, A2h. B3d1.

COMPLETE SPECIFICATION

## Improved Method and Apparatus for the Continuous Crystallization *in Vacuo* of Sugar Solutions and the Like

I, GEORGES LOUIS WILLAIME, a Citizen of the French Republic, of 32 rue Desbordes-Valmore, Paris XVI°, France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has for its object a method and apparatus for the continuous crystallization *in vacuo* of sugar solutions and the like.

According to the invention there is provided a method for the continuous crystallization *in vacuo* of sugar and like solutions, in which method the solution to be crystallized is fed to the first of a series of heated and interconnecting compartments to commence the crystallization and evaporation of the solution, the resulting mass being continuously caused to flow therefrom through the succeeding compartments to increase the crystal size, in each of which compartments the mass receives a continuous controlled additional supply of solution to be crystallized, the displacement of the mass to ensure its constant progression through the apparatus being obtained by a difference in the level of the mass undergoing crystallization between successive compartment or by a difference of pressure between successive compartments.

The first of said compartments is adapted to receive the solution to be crystallized which may be fed thereto through concentrating means at a point near saturation point.

A crystalline powder may be fed in a continuous or periodically interrupted manner into said solution either inside the first compartment or else directly into the solution before it enters the said compartment.

The solution after it has passed in succession through all the compartments may be admitted to an open or closed crushing device operating in open relationship with the atmosphere or *in vacuo*.

It is also possible in certain cases to insert in series two mixers or crystallizers of which one operates *in vacuo* and is located at the same level as the continuously operating boiler while the second, which operates in free communication with the atmosphere, is located at a lower level and is connected with the first crushing device through a barometric tube.

Said method may be executed either with an apparatus of the vertical type or of the horizontal type.

The accompanying drawing shows by way of example, two forms of execution of the invention. In said drawing:

Figures 1 and 2 are respectively a vertical cross-section through the line 1—1 of Figure 2 and a horizontal cross-section through line 11—11 of Figure 1 of a vertical apparatus according to the invention.

Figure 3 shows a modification of Figure 1.

Figures 4, 4a and 4b are diagrammatic views of a horizontal apparatus whereof Figure 4 is a longitudinal cross-section. Figure 4a a transverse cross-section through line IV—IV of Figure 4, and Figure 4b is a modification of the cross-section shown in Figure 4a.

Figure 5 shows diagrammatically a multiple arrangement of the same type.

Referring to Figures 1 and 2, an annular chamber constituted by a vertical axial tube 1 and a co-axial casing 2 is subdivided into a series of compartments five for instance, $3^1$, $3^2$, $3^3$, $3^4$, $3^5$ by means of radial partitions 3 extending from the bottom of the casing up to an inverted cap-member 4 secured to the upper portion of said casing, which cap-member is covered by a dome 5 connected with a condenser; said compartments having increasing volumes from the first to the last.

Said annular chamber at its lower part is provided with a tubular heating bundle 6 common to all the compartments or itself divided into compartments. Said bundle is provided with a steam inlet 7 fed preferably

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by a multiple effect evaporating apparatus.

During operation, the crystallizing mass introduced in the first place inside the compartment $3^1$ rises through the pipes of the tubular bundle 6 (Figure 1) and sinks then into the annular space 8 provided between the heating bundle and the axial tube 1. Said circulation furthers the evaporation and crystallization process. However, an excess portion of the mass carrying along with it the majority of the larger crystals passes through an opening 9 into the following compartment $3^2$ by reason of the principle of communicating vessels. This movement is moreover controlled by an umbrella-shaped deflector 10 and by a small radial partition 11 and subsequently by similar partitions $11^1$, $11^2$, $11^3$.

As a matter of fact, the mass of liquid has to flow in succession through the compartments $3^1$, $3^2$, $3^3$, $3^4$, $3^5$, the four first compartments serving more particularly for the increase in size of the crystals, while the latter is intended for the exhausting and the tightening of the mass for increasing its compactness. This being effected, the mass is removed in a continuous manner from the compartment $3^5$ through overflow means constituted by an opening 12 provided in the axial tube 1. Said opening is adjustable and the mass flowing through it enters the axial tube which leads it to the mixing or crystallizing means described above.

The displacement of the mass is obtained either through a slight difference in the level of the solution undergoing crystallization between the successive compartments or by reason of a slight difference in pressure between said compartments as obtained through a suitable adjustment of the steam outlet cross-section of the ports 13, $13^1$, $13^2$, which adjustment is provided by means of suitably designed dampers or throttle valves. The exhaust of the mass may be executed through the agency of a pump delivering it to the crushing devices.

Furthermore, each compartment receives through an adjustable cock, a continuous flow of a saturated or not quite saturated solution, the richness or purity of which remains constant or better still decreases from one compartment to the next. This flow is adjusted if required by automatic means so as to maintain the mother liquor in a state of optimum super-saturation with a view to obtaining the desired crystallization.

At the same time, the steam pressure is adjusted inside the tubular bundle 6 so as to properly associate the progression of the simultaneous processes of evaporation and of crystallization. This adjustment may also be executed automatically and auxiliary heating may be provided through a double bottom. In exceptional cases, it is possible to adjust the heating by acting on the proportion of incondensable gases in the upper portion of the bundle 6.

The adjustment of the speed of evaporation as a whole may be obtained by acting on the degree of vacuum inside the dome 5 and the pipe connecting said dome with the condenser will be advantageously provided with an automatic vacuum regulator.

Obviously moreover this form of execution of the invention is illustrated only in a purely diagrammatic manner and it may include any detail additions as well as any constructional modifications.

Thus for instance, the tubular bundle 6 may be arranged as shown in Figure 3, said bundle being secured directly to the axial tube 1 in which case the annular space 8 surrounds the bundle so as to provide in each compartment for the circulation of the mass undergoing treatment in the space between the bundle and the outer casing 2.

Figures 4, 4a and 4b show also in a diagrammatic manner an arrangement for the execution of the invention in horizontal apparatus. The body 14 of said apparatus carries along its longitudinal axis a tubular heating bundle 15 the shape of which as illustrated in Figure 4a is that of an upwardly convex sector provided with cylindrical or frusto-conical tubes or else, as in the case illustrated in Figure 4b, that of two opposite sectors 16 and 16*a* provided with curvilinear tubes. On the other hand, the body 14 of the apparatus is subdivided into a plurality of compartments, four in the case considered, by means of vertical partitions 17, as illustrated in Figure 4. In said case, the body 14 is shown as frusto-conical and the volume of the compartments increases gradually. Obviously this increase in volume may be obtained as well in a cylindrical body by spacing the partitions at increasing distances; or again as shown in the plan view Figure 5, it is possible to juxtapose twin cylindrical apparatus arranged in tandem with a first apparatus also cylindrical. In a horizontal apparatus of considerable length and providing for continuous boiling, the partitions 17 dividing the body into compartments should be very reduced and even appear as mere reinforcing members for the tubular bundle 15 or 16.

The circulation in each compartment is provided as shown by the arrows in Figures 4a and 4b and the operation is identical with that described above. The mass which is being crystallized passes from one compartment to the next through the ports 9 provided at the lower end of each partition 17 and is let out of the last compartment into a mixing or crystallizing apparatus 18 located at a lower level and communicating with the atmosphere.

It is of interest to point out that a large

plant provided with a plurality of intermittent boiling apparatus may be transformed for continuous boiling operation in accordance with the invention by interconnecting in series the different apparatus adapted to treat the same liquid. In this case there is adopted an increasing progression in the volume as in the heating surface of the different relays except in certain cases as concerns the surface of the last apparatus intended to tighten the material.

The invention shows numerous advantages. In the case of the treatment of sugar solutions, it allows the use of heavier syrups and of less hot juice vapours, which leads to a substantial economy in fuel. Moreover, as a lesser total useful capacity is required for the boiling apparatus, it is possible to operate at a lower level and temperature whereby a smaller amount of sugar is destroyed and the syrup water is less coloured.

In its application to any other industries, the invention allows, in a general sense, in addition to an economy in fuel, a greater ease in the control of the crystallization, the obtainment of more regular grains and an increased possibility of using automatic controlling and adjusting the apparatus for the boiling process.

HAVING NOW particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A method for the continuous crystallization *in vacuo* of sugar and like solutions, in which method the solution to be crystallized is fed to the first of a series of heated and interconnecting compartments to commence the crystallization and evaporation of the solution, the resulting mass being continuously caused to flow therefrom through the succeeding compartments to increase the crystal size, in each of which compartments the mass receives a continuous controlled additional supply of solution to be crystallized, the displacement of the mass to ensure its constant progression through the apparatus being obtained by a difference in the level of the mass undergoing crystallization between successive compartments or by a difference of pressure between successive compartments.

2. A method for the continuous crystallization of solutions as claimed in Claim 1, in which the additional supply of solution to the separate compartments is of an equal or gradually decreasing purity from one compartment to the next.

3. A method for the crystallization of solutions as claimed in Claim 1, in which a crystalline powder is fed to the solution either immediately prior to its entrance to the first compartment or within the compartment itself.

4. A method for the crystallization of solutions as claimed in Claim 1, in which the treated mass on leaving the last compartment is transferred to one or more mixers or crystallizers through intermediary means adapted to compensate for differences in pressure.

5. Apparatus for carrying out the method as claimed in Claim 1, comprising a series of separate compartments in order of increasing capacity having orifices formed in their dividing walls to enable the continuous flow of the mass from one compartment to the next to occur due either to a reduction in pressure in successive compartments or to a reduction of the level of the mass in successive compartments, means feeding an additional controlled amount of solution to each compartment, heating means located in each compartment, and means common to all compartments for producing a vacuum and for exhausting and condensing the vapours in each compartment.

6. Apparatus as claimed in Claim 5, wherein the compartments form successive sectors of a vertical cylinder, the successive sectors having tubular heating elements of increasing number.

7. Apparatus as claimed in Claim 6, wherein the treated mass flows from the bottom to the top of the heating element and thereafter sinks through an annular space provided in the compartment to pass through the connecting orifice to the next compartment.

8. Apparatus as claimed in Claim 5 or Claim 7, in which the connecting orifice is provided with a deflector plate to guide the flow of the mass therethrough.

9. Apparatus as claimed in claim 6, wherein the tubular heating elements in each compartment are fed from a common source.

10. Apparatus as claimed in any one of claims 5 to 9, wherein each compartment is provided with an adjustable steam outlet port connected to the common exhausting and condensing means whereby the pressure in each compartment may be regulated.

11. Apparatus as claimed in claim 6, and comprising a central co-axial tube extending through the bottom of the apparatus to a point above the level of the liquid therein and having an adjustable slot in communication with the last and largest compartment for the controlled removal of the crystallized product.

12. Apparatus as claimed in claim 6, in which a double bottom is fitted to the vertical cylinder through which additional heat may be applied.

13. Apparatus as claimed in claim 5, comprising a series of juxtaposed co-axial compartments of successively increasing volume, forming a horizontal chamber, the succes-

sive compartments being provided with tubular heating bundles of successively increasing heating surface.

14. Apparatus as claimed in any one of claims 5 to 9 and 11 to 13, wherein the movement of the mass through the apparatus is ensured by a successive lowering of the level of the mass in each succeeding compartment.

15. The method of continuously crystallizing solutions substantially as hereinbefore described with reference to the accompanying drawing.

16. Apparatus for continuously crystallizing solutions substantially as hereinbefore described with reference to the accompanying drawing.

17. Crystals whenever prepared or produced by the method claimed in any one of claims 1 to 4 and 15.

Dated this 3rd day of May, 1946.

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FIG.1.

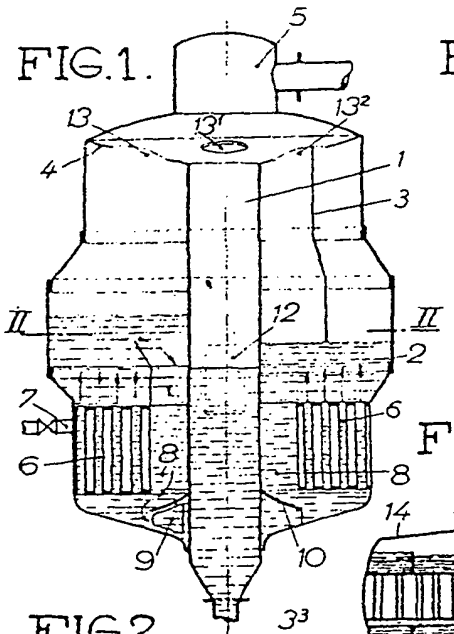



FIG.3.

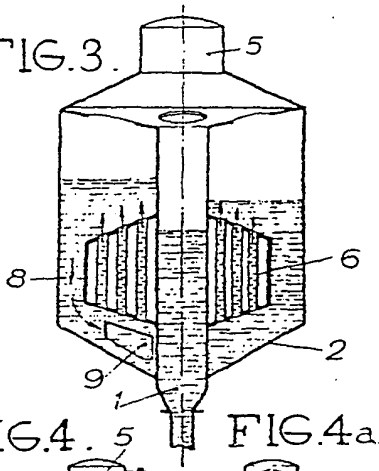



FIG.2.

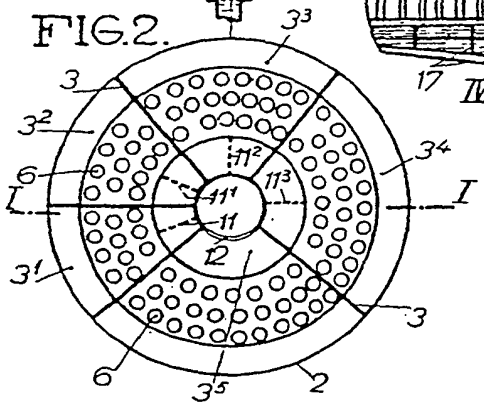



FIG.4.

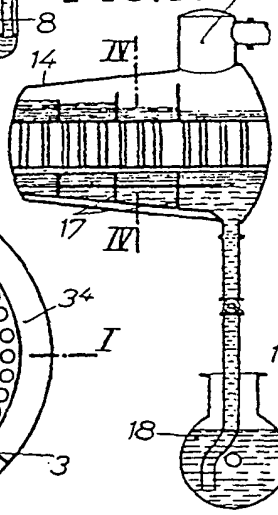



FIG.4a.

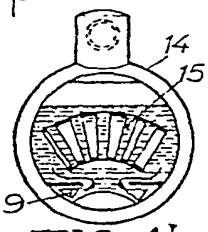



FIG.4b.

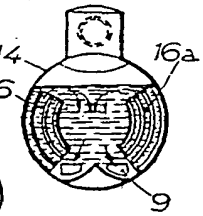
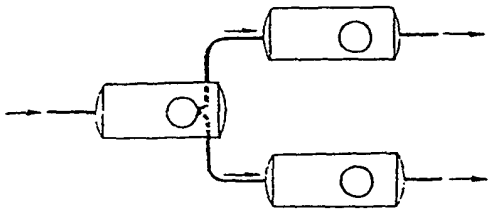



FIG.5.



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